Claims

[c1] A method of forming a thermal barrier coating (26) on a surface of a component (10), the method comprising the step of forming the thermal barrier coating (26) of a thermal-insulating material in which is contained elemental carbon and/or a gas that is insoluble in the thermal-insulating material, the elemental carbon and/or insoluble gas being within pores (32) that are within grains and at and between grain boundaries of the thermal-insulating material, the elemental carbon and/or the insoluble gas being present in an amount sufficient to thermally stabilize the microstructure of the thermal-insulating material.

[c2] A method according to claim 1 wherein the forming step comprises co-evaporating carbon and a thermal-insulating material at an elevated temperature.

[c3] A method according to claim 2, wherein the forming step comprises depositing the thermal barrier coating (26) by electron beam physical vapor deposition during which an ingot of the thermal-insulating material and an ingot of a carbon-containing or carbide-containing material are simultaneously evaporated.

[c4] A method according to claim 1, wherein the forming step comprises depositing the thermal barrier coating (26), infiltrating the thermal barrier coating (26) with the insoluble gas, and then heating the thermal barrier coating (26) to close at least some of the pores (32) and entrap the insoluble gas within the closed pores (32).

[c5] A method according to claim 4, wherein the insoluble gas is at least one gas chosen from the group consisting of carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen and argon.

[c6] A method according to claim 1, wherein at least some of the pores (32) entrap the insoluble gas, the pores (32) containing the insoluble gas being resistant to sintering, grain coarsening and pore redistribution.

[c7] A method according to claim 6, wherein the insoluble gas is a carbon-

containing gas that is entrapped by heating the thermal barrier coating (26) to a temperature sufficient to evolve the carbon-containing gas from the elemental carbon and partially sinter the thermal-insulating material to close at least some of the pores (32).

[c8] A method according to claim 7, wherein the heating step is performed at a temperature of at least 950 ° C.

[c9] A method according to claim 1, wherein the thermal barrier coating (26) comprises columnar grains (30).

[c10] A method according to claim 1, wherein the thermal-insulating material is yttria-stabilized zirconia.

[c11] A method of forming a thermal barrier coating (26) on a surface of a component (10), the method comprising the step of forming the thermal barrier coating (26) at an elevated temperature by co-evaporating carbon and a thermal-insulating material to thermally stabilize pores (32) within the microstructure of the thermal-insulating material.

[c12] A method according to claim 11, wherein the forming step comprises depositing the thermal barrier coating (26) by electron beam physical vapor deposition during which an ingot of the thermal-insulating material and a second ingot of a carbon-containing or carbide-containing material are simultaneously evaporated.

[c13] A method according to claim 12, wherein the second ingot comprises graphite.

[c14] A method according to claim 11 wherein, as a result of the forming step, the thermal barrier coating (26) has a microstructure with pores (32) and sub-grain interfaces within, at and between grain boundaries of the microstructure, the pores (32) establishing an open porosity within the thermal barrier coating (26) that constitutes at least 25 volume percent of the thermal barrier coating (26), at least some of the pores (32) containing elemental carbon and/or a carbon-containing gas, the elemental carbon and/or the carbon-containing gas being present in an amount sufficient to thermally stabilize the microstructure of the

thermal-insulating material.

[c15] A method according to claim 14, wherein at least some of the pores (32) entrap the carbon-containing gas, the pores (32) containing the carbon-containing gas being resistant to sintering, grain coarsening and pore redistribution.

[c16] A method according to claim 14 further comprising the step of heating the thermal barrier coating (26) to a temperature sufficient to evolve the carbon-containing gas from the elemental carbon and partially sinter the thermal-insulating material to close at least some of the pores (32).

[c17] A method according to claim 16, wherein the heating step is performed at a temperature of at least 950 ° C.

[c18] A method according to claim 14 further comprising the step of heating the thermal barrier coating (26) to a temperature sufficient to evolve the carbon-containing gas from the elemental carbon and form additional pores (32) that entrap the carbon-containing gas.

[c19] A method according to claim 18, wherein the heating step is performed at a temperature of at least 950 ° C.

[c20] A method according to claim 11, wherein the thermal-insulating material is yttria-stabilized zirconia and the thermal barrier coating (26) comprises columnar grains (30).

[c21] A method of forming a thermal barrier coating (26) on a surface of a component (10), the method comprising the steps of:

depositing the thermal barrier coating (26) on the surface of the component (10), the thermal barrier coating (26) has a microstructure with pores (32) and sub-grain interfaces within, at and between grain boundaries of the microstructure;

infiltrating the thermal barrier coating (26) with a gas that is insoluble in the thermal-insulating material; and then

heating the thermal barrier coating (26) to close at least some of the pores (32) and entrap the insoluble gas within the closed pores (32).

[c22] A method according to claim 21, wherein the insoluble gas is at least one gas chosen from the group consisting of carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen and argon.

[c23] A method according to claim 21, wherein the depositing step is performed by electron beam physical vapor deposition.

[c24] A method according to claim 21, wherein the heating step is performed at a temperature of at least 950 ° C.

[c25] A method according to claim 21, wherein the thermal-insulating material is yttria-stabilized zirconia and the thermal barrier coating (26) comprises columnar grains (30).

[c26] A thermal barrier coating (26) on a surface of a component (10), the thermal barrier coating (26) comprising a thermal-insulating material in which is contained elemental carbon and/or a gas that is insoluble in the thermal-insulating material, the elemental carbon and/or insoluble gas being within pores (32) that are within grains and at and between grain boundaries of the thermal-insulating material, the elemental carbon and/or the insoluble gas being present in an amount sufficient to thermally stabilize the microstructure of the thermal-insulating material.

[c27] A thermal barrier coating (26) according to claim 26, wherein at least some of the pores (32) contain the elemental carbon.

[c28] A thermal barrier coating (26) according to claim 26, wherein at least some of the pores (32) entrap the insoluble gas.

[c29] A thermal barrier coating (26) according to claim 28, wherein the insoluble gas is at least one gas chosen from the group consisting of carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen and argon.

[c30] A thermal barrier coating (26) according to claim 26, wherein at least some of the pores (32) contain the elemental carbon and at least some of the pores (32) entrap the insoluble gas, the insoluble gas being a carbon-containing gas.

[c31] A thermal barrier coating (26) according to claim 26, wherein the microstructure of the thermal barrier coating (26) comprises columnar grains (30).

[c32] A thermal barrier coating (26) according to claim 26, wherein the thermal-insulating material is predominantly yttria-stabilized zirconia.

[c33] A thermal barrier coating (26) according to claim 26, wherein the thermal barrier coating (26) has an open porosity level of at least 25 volume percent.

[c34] A thermal barrier coating (26) on a surface of a superalloy component (10), the thermal barrier coating (26) comprising:
a bond coat (24) on the component (10);
a thermal-insulating material having a columnar microstructure with pores (32) and sub-grain interfaces within, at and between grain boundaries of the microstructure, at least some of the pores (32) containing elemental carbon and/or a carbon-containing gas to resist sintering, grain coarsening and pore redistribution within the thermal-insulating material and thereby thermally stabilizing the microstructure.

[c35] A thermal barrier coating (26) according to claim 34, wherein the thermal-insulating material is yttria-stabilized zirconia.

[c36] A thermal barrier coating (26) according to claim 34, wherein at least some of the pores (32) entrap the carbon-containing gas.

[c37] A thermal barrier coating (26) according to claim 36, wherein the entrapped carbon-containing gas is carbon monoxide.

[c38] A thermal barrier coating (26) according to claim 34, wherein the thermal barrier coating (26) has an open porosity level of at least 25 volume percent.